J.F. O'Connor. 1982

Changes in the characteristics of the Playgreen Lake whitefish *(Coregonus clupeaformis)* population 1975-1981.

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Changes in the characteristics of the Playgreen Lake whitefish *(Coregonus clupeaformis)* population 1975-1981.

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ABSTRACT

Data collected during the 1975 to 1981 commercial sampling program and 1981 experimental fishing program were evaluated to determine if any changes had occurred in the Playgreen Lake whitefish fishery which could be directly attributed to the opening of 2-Mile Channel. The mean weight of fish in the commercial catch has decreased 35.8% and there has been a significant decline in whitefish growth rates through the period 1976-1981. Growth declines may not be density-related compensatory responses since numbers delivery^{-1} have not increased. Numbers delivery^{-1}, however, may be limited by netting efficiency. Ecological monitoring data on primary and secondary productivity are unavailable and it is not known if declines in trophic levels in the lake have affected growth rates. The mean length and weight reduction in the catch between 1979 to 1981 may be partially attributable to the use of smaller mesh in the commercial fishery which may be selectively exploiting the faster growing fish in the recruited cohorts. Declines in annual catch delivery^{-1} appears to be primarily related to

growth declines and quota expansions which have caused fishermen to fill their quota by continuing to fish during the warm weather season when whitefish catches decline. Slow growth, old age composition, Abrasov's index, high survival rates, and number of contributing year classes in the commercial fishery infer that the whitefish fishery is undergoing moderate exploitation. The experimental fishing program initiated in 1981 should continue in order to monitor growth, density and maturity indices and Landsat digital data should be used for trend-through-time quantitative mapping of sediment levels.

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INTRODUCTION

Whitefish *(Coregonus clupeaformis)* have been the dominant species in the Playgreen Lake fishery since the lake was first fished in the 1930's. During the earlier years the level of harvest was largely controlled by the intensity of fishing effort. Whitefish yields fluctuated from 4,760 kg in 1938 to 138,450 kg in 1959 as the number of licences issued varied from 11 to 225. In 1968, the number of licences was limited to 50 by the Norway House Fishermens Cooperative. This action appeared to stabilize the whitefish stock and catches improved. The lake quota has doubled since 1968 to the current level of 226,800 kg of walleye *(Stizostedion vitreum)*, sauger *(Stizostedion canadense)* and whitefish, while the catch per licence of whitefish has increased from 1484 kg to 3523 kg.

The limnological characteristics of Playgreen Lake have never been thoroughly studied. Schlick (1972) conducted a baseline inventory on the lake to gather sufficient information to determine the commercial quota using Ryder's (1965) index. Sopuck (1978), after examining catch and licence data from 1940 to 1977 and evaluating commercial sampling data from 1975, 1976 and 1977, concluded that the whitefish stocks were healthy and could withstand increased exploitation.

The Lake Winnipeg, Churchill Nelson Study Board (1974) reviewed the environmental implications of hydroelectric development,

specifically 2-Mile Channel, on the biology of Playgreen Lake (Fig. 1) with inconclusive results. It was suspected that during periods of high southerly winds at the 2-Mile Channel entrance, more suspended sediments would enter the lake via 2-Mile Channel than through Warren Landing entrance. However, since primary productivity was already inhibited by high turbidity levels in Playgreen Lake, the additional sediment load was not expected to reduce primary production significantly. The report also suggested that sedimentation below 2-Mile Channel outlet could possibly result in declines in benthos production in the south basin.

Sediment transfer studies carried out by Manitoba Hydro (1979) at the inlet and outlet of 2-Mile Channel during the 1971-1977 period indicated that the concentration of suspended sediments was primarily a function of wind, storm duration, distance from shoreline, shoreline type and possibly water depth. Materials in suspension were predominantly colloidal, originating from the glacial lake clays which formed the old Lake Agassiz bed; mixing appeared thorough and little stratification occurred. Their data showed that suspended sediment levels varied exponentially with wind velocity and the variability of suspended sediments was restricted to 600 meters from shore (Appendices 1 and 2).

In 1971, Manitoba Hydro sampled the sediment bedload in the Warren Landing area to determine the littoral drift of larger particles, not in full suspension, moving along the channel and lake bottom. Significant bedload movement was detected in

Warren Landing channel but bedload movements along the shorelines of Lake Winnipeg and Playgreen Lake were oscillatory and occurred during periods of high winds. Little evidence was found of littoral drift. The program was discontinued due to costs and variability of results under different climatic conditions.

The earthen plug in 2-Mile Channel was removed in July, 1976. In 1979 and 1981, the Geotechnical Department of Manitoba Hydro conducted morphometric surveys along 2-mile channel to monitor erosional processes (Kulak 1981). Bottom erosion up to 0.3 meter had occurred along the entire length of the channel. A 6 meter widening of channel sides below the water line had developed at the inlet and at one test site near the outlet, significant beaching had widened the channel 15 meters at the water line.

The LWCNSB (1974) reported that diversion of water through 2-mile channel could disrupt the migratory pattern of spawning whitefish from Lake Winnipeg to Playgreen Lake. Tagging studies and observations of fishermen suggest that there is an autumn run of spawning whitefish from Lake Winnipeg through Warren Landing channel into the Norway House area of Playgreen Lake (Pollard 1973). One theory on whitefish movements is that the fish move through the north basin in a clockwise direction. In this case, any spawners moving from the west towards Warrens Landing may become disoriented by discharges encountered as they

moved past 2-Mile Channel. Campbell (pers. comm.) tagged 1423 whitefish in Lake Winnipeg and 845 in Playgreen Lake within 1.5 km of 2-Mile Channel during September 25-30, 1978 to monitor movements between lakes. Fishermen, traditionally reluctant to return tags, have returned few. Eight of 13 tags recovered from Lake Winnipeg were tagged on the Playgreen Lake side of the channel and 3 of 9 tags recovered in Playgreen Lake were tagged and released in Lake Winnipeg. To date, there have been insufficient tag returns from the 1978 project to support or clarify theories on the seasonality of whitefish movements.

This report reviews the whitefish fishery and documents changes in yields and characteristics of the stock from 1975 to 1981. Since hydrological, limnological, trend-through-time experimental fishing data and tag return data are either incomplete or unavailable, there remains several unanswered questions on the effects of any change in environmental parameters on stock density. There was sufficient information available, however, from annual commercial sampling programs and Freshwater Fish Marketing Corporation's delivery records to explain some of the changes fishermen have noticed in their catch in recent years.

METHODS

Experimental Netting

Experimental fishing was conducted in Playgreen Lake during the period of June 5-9, 1981. Seven gangs of nylon gillnets of 51, 77, 96, 108, 121 and 134 mm stretched measure panels were fished overnight for 16 - 20 hour duration. Each panel was 45.72 m long and 1.83 m deep.

Each whitefish taken in the experimental nets was measured for fork length to the nearest 2 mm. Weights were recorded to the nearest 25 g on a Accu-Weigh (DSM 25 PK) spring scale. The first 2 rays of the pelvic fin were removed for age determination. Gonads were examined for visual identification of sex and state of maturation. Size of mesh capturing each sampled specimen was recorded.

Commercial Sampling

Description of the 1975, 1976 and 1977 commercial sampling programs are provided in Sopuck's (1978) report on Playgreen Lake. Sampling data presented in Sopuck's report have been analyzed further for growth relationships. Sopuck's estimates of number of whitefish in each age class in the commercial fishery were corrected using conversion ratios of marketed to round weights from FFMC's landing records.

On June 15 and 16, 1978, 394 whitefish, 269 from 108 mm mesh and 125 from 134 mm mesh, were sampled from commercial

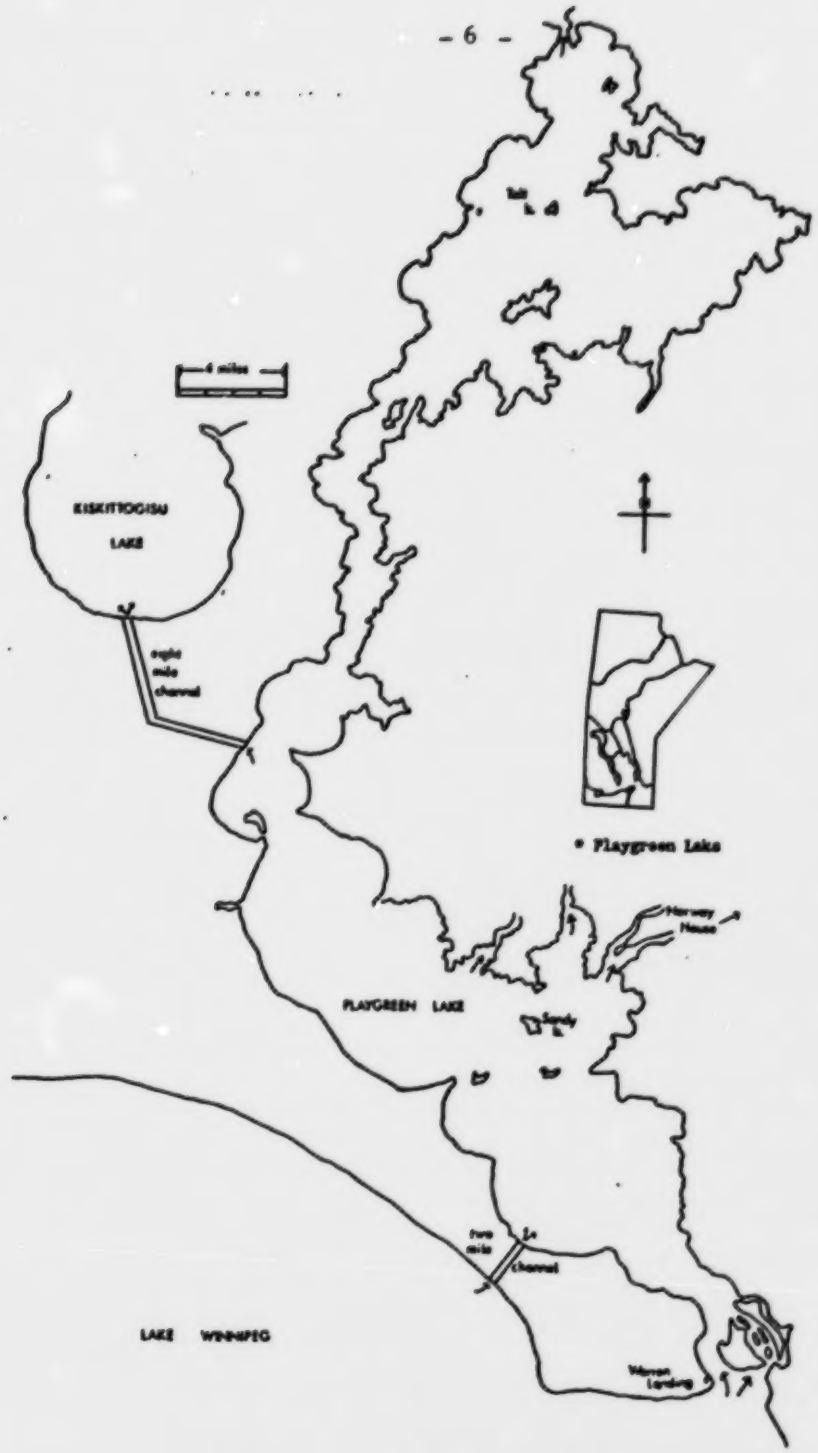

Figure 1. Map of Playgreen Lake.

fishermens catches. Lengths, weights and ageing structures were sampled according to the procedures outlined in the experimental netting section. Dressed weights were converted to round weights using a 12% conversion factor (Doan 1959).

The 1979 commercial sample, taken during July 17 and 18, was composed of 238 fish from 108 mm mesh and 121 from 134 mm mesh.

The 1980 sample was taken with 96, 108, 128 and 134 mm mesh gangs. The 128 mm mesh, which is not a legal size mesh in the fishery, was added to provide statistical data on the selectivity indices of this mesh size. The 96 mm mesh was added to capture immature year classes for maturity studies. Maturation rates were not calculated, however, since the September 23-25 sampling project intercepted a spawning run and only 9 of the 811 fish sampled were immature.

Commercial sampling was conducted on June 2-4 in 1981. The sample was composed of 395 fish captured by 108 mm mesh and 53 from the 134 mm mesh.

The techniques used for mounting and ageing fin rays are described by Erickson (1979). Erickson found close agreement between fin ray ages and scale ages of exploited populations of whitefish in Lake Winnipeg. In 1977, the ageing structure sample from Playgreen whitefish was changed from scales to fin rays. Although Playgreen Lake is moderately to intensively fished, changing the ageing structure did appear to improve accuracy and correct biases in

descriptive characteristics of older fish in the fishery.

Routine statistical analyses were performed according to Snedecor and Cochran (1967). Lysack (1981) describes the transformation and equation used to calculate the maturation curve. The mean weighted age of onset of sexual maturity was estimated by a modified version of Abrosov's (1967) formula. Growth analyses techniques used are described by Ricker (1975). Survival rates were determined by Robson and Chapman (1961) method and by linear regressions on log transformed data from the descending limits of catch curves. Estimates of the number of whitefish in each age class in the commercial fishery were made using the method of Cucin and Regier (1966).

RESULTS

Sample Descriptions and Growth Regimes

Statistical descriptions of the commercial samples in terms of percent age composition, age specific mean fork lengths, mean weights and mean condition factors for the period 1975-1981 are provided in Tables 1-7. The salient features of the commercial catches during the 1975-81 period, age range, mean ages, lengths, weights and condition factors are summarized in Table 8. Mean age of the commercial sample increased through the period, 1975 to 1977 from 6.02 to 7.8, then declined steadily to 5.51 in 1980 and then abruptly increased to 8.27 years in 1981. The mean lengths and weights peaked in 1976, and, except for an increase in mean weight in the July 1979 commercial sample, have declined steadily since then to a level where the 1981 fish were 37 mm shorter and 520 gm (35.8%) less than the average size in 1976. The average condition factors peaked in 1979 at 1.71 and declined sharply to 1.39 in 1981.

The age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish caught in the 108, 128 and 134 mm mesh fished by a commercial fishermen in 1980 are provided in Tables 9, 10 and 11 respectively. The selectivity of gillnets is clearly shown by all descriptive population characteristics; age, size, year classes and condition factors increased with increasing mesh size. Although larger mesh is selective for the larger fish in any given age group, covariance

Table 1. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from commercial nets (108 mm) Playgreen Lake, July 1975

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
4	6	2.58	374.00	7.72	715.00	23.77	1.38
5	80	34.33	405.35	1.77	953.88	11.90	1.43
6	81	34.76	425.28	2.20	1112.84	14.88	1.45
7	41	17.60	450.66	2.45	1338.29	21.87	1.46
8	19	8.15	459.74	3.80	1393.68	39.08	1.44
9	6	2.58	467.17	6.35	1618.33	79.85	1.59
Mean 6.02			425.12		1123.61		1.45

Table 2. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from commercial nets (133 mm) Playgreen Lake, June 1976

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
4	3	0.63	349.67	3.28	606.67	29.63	1.42
5	40	8.44	382.55	3.44	928.50	19.57	1.66
6	77	16.24	416.87	2.28	1183.77	17.66	1.63
7	150	31.65	438.73	1.47	1385.40	12.00	1.64
8	105	22.15	457.41	2.11	1585.05	20.55	1.65
9	54	11.39	470.89	2.09	1769.26	30.77	1.69
10	37	7.81	482.22	3.95	1916.49	55.37	1.70
11	6	1.27	493.50	11.31	2110.00	92.88	1.76
12	2	0.42	488.00	5.00	2250.00	100.00	1.94
Mean 7.40			441.97		1451.39		1.66

Table 3. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from commercial nets (108 mm) Playgreen Lake, June 1977

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
4	1	0.39	359.00		650.00		1.40
5	9	3.53	382.44	6.24	811.11	34.13	1.45
6	43	16.86	413.14	3.58	1077.91	24.19	1.53
7	57	22.35	433.09	2.11	1244.74	18.55	1.53
8	69	27.06	447.72	2.14	1357.25	20.18	1.51
9	43	16.86	460.07	2.77	1465.12	33.47	1.50
10	23	9.02	471.91	4.04	1613.04	44.03	1.53
11	5	1.96	468.40	10.17	1660.00	133.60	1.61
12	5	1.96	487.00	7.32	1980.00	146.29	1.70
Mean 7.80			441.41		1322.35		1.52

Table 4. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from commercial nets (108 and 133 mm) Playgreen Lake, June 1978

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
4	2	0.49	401.00	9.00	966.0	12.50	1.50
5	53	13.05	393.75	2.98	871.17	15.48	1.43
6	141	34.73	400.42	2.02	931.15	12.36	1.45
7	67	16.50	409.04	2.83	1003.85	19.49	1.47
8	42	10.34	425.26	4.51	1164.0	36.41	1.51
9	45	11.08	450.87	4.20	1365.78	36.58	1.49
10	38	9.36	456.58	4.11	1402.2	34.12	1.47
11	14	3.45	471.71	4.26	1484.0	36.12	1.41
12	3	0.74	454.00	18.82	1474.67	218.58	1.58
13	1	0.25	463.00		1344.0		1.35
Mean 7.17			417.33		1077.59		1.48

Table 5. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from commercial nets (108 and 133 mm) Playgreen Lake, July 1979

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
3	2	0.56	387.00	26.00	901.60	115.00	1.56
4	37	10.31	373.46	3.40	879.53	23.39	1.68
5	93	25.91	391.29	2.02	1003.42	14.12	1.67
6	108	30.08	409.45	1.80	1180.36	16.40	1.72
7	68	18.94	433.56	3.39	1405.11	25.78	1.72
8	31	8.64	452.16	3.94	1537.65	28.27	1.66
9	14	3.90	463.86	5.37	1792.0	64.15	1.79
10	4	1.11	476.50	15.56	1820.0	173.81	1.68
11	1	0.28	517.00		1948.80		1.41
12	1	0.28	494.00		2408.00		2.00
Mean 6.01			412.57		1211.72		1.71

Table 6. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from commercial nets (108 and 133 mm) Playgreen Lake, September 1980

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
3	2	0.40	376.00		830.00		1.56
4	62	12.53	390.90	3.31	866.29	19.94	1.45
5	210	42.42	408.94	1.67	986.48	11.66	1.44
6	155	31.31	421.11	2.04	1124.00	17.41	1.50
7	45	9.09	440.58	3.74	1308.67	38.52	1.53
8	15	3.03	458.93	6.29	1370.00	62.67	1.42
9	3	0.61	502.00	1.15	1660.00	170.10	1.31
10	3	0.61	506.00	22.27	1870.00	185.02	1.44
Mean 5.51			415.90		1064.20		1.48

Table 7. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from commercial nets (108 and 133 mm) Playgreen Lake, June 1981

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
5	12	2.68	363.58	5.49	684.19	28.96	1.42
6	47	10.51	383.36	2.58	803.30	11.35	1.43
7	80	17.90	394.04	1.89	858.97	13.59	1.40
8	125	27.96	405.00	1.72	926.33	11.51	1.39
9	94	21.03	409.43	2.12	959.57	13.80	1.40
10	51	11.40	416.49	3.21	992.62	22.39	1.37
11	23	5.15	436.48	4.69	1156.13	43.00	1.39
12	10	2.24	440.00	9.88	1130.08	61.31	1.33
13	4	0.89	465.25	23.74	1388.80	165.88	1.38
14	1	0.22	400.00		1568.0		1.61
Mean 8.27			404.96		931.35		1.39

Table 8. Mean ages, lengths, weights and condition factors of whitefish in the commercial fishery, Playgreen Lake 1975-1981.

Year	N	Age Range	Mean Age	Mean length (mm)	Mean weight (gm)	Mean condition factor
1975	233	4-9	6.02	425.12	1123.61	1.45
1976	474	4-12	7.40	441.97	1451.39	1.66
1977	255	4-12	7.80	441.41	1322.35	1.52
1978	384	4-13	7.17	417.33	1077.59	1.48
1979	359	3-12	6.01	412.57	1211.75	1.71
1980	495	3-10	5.51	415.90	1064.20	1.48
1981	447	5-14	8.27	404.96	931.35	1.39

Table 9. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from 108 mm mesh net Playgreen Lake, September, 1980

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
3	1	0.40	378.00		740.00		1.37
4	49	19.84	388.00	2.31	840.41	16.41	1.44
5	132	53.44	407.38	1.60	961.74	10.55	1.42
6	59	23.89	419.69	2.34	1091.02	22.26	1.47
7	4	1.62	421.50	8.50	1087.50	74.65	1.45
8	2	0.81	455.00	11.00	1400.00	0.00	1.49
Mean 5.09			409.00		973.2		1.44

Table 10. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from 128 mm mesh net Playgreen Lake, September 1980.

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
4	28	11.38	396.86	2.13	909.64	16.45	1.45
5	112	45.53	407.29	1.34	983.57	11.11	1.45
6	79	32.11	418.73	1.74	1068.61	13.26	1.45
7	17	6.91	447.76	6.44	1304.71	52.62	1.44
8	9	3.66	473.11	5.55	1481.11	56.78	1.40
9	1	0.41	462.00		1300.00		1.32
Mean 5.47			415.21		1044.15		1.45

Table 11. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from 133 mm mesh net Playgreen Lake, September 1980

Age	N	%	Mean length	1SE	Mean wt	1SE	Mean C.F.
3	1	0.40	374.00		920.00		1.76
4	13	5.24	401.85	7.08	963.00	33.25	1.51
5	78	31.45	411.59	1.78	1028.33	13.55	1.47
6	96	38.71	421.98	1.86	1144.27	14.44	1.52
7	41	16.53	442.44	9.28	1330.24	35.00	1.53
8	13	5.24	459.54	5.56	1365.38	72.31	1.39
9	3	1.21	502.00	1.15	1660.00	170.10	1.31
10	3	1.21	506.00	22.27	1870.00	185.02	1.44
Mean 5.93			424.80		1154.80		1.50

analyses of length and weight at age data for age groups 4-8 of whitefish caught in the 3 mesh sizes produced no significant differences in slopes ($F = 1.43$, 2 and 9 d.f., $P = 0.01$) and elevations ($F = 3.08$, 2 and 11 d.f., $P = 0.01$) of growth curves of untransformed lengths or slopes ($F = 0.83$, 2 and 9 d.f., $P = 0.01$) and elevations ($F = 3.04$, 2 and 11 d.f., $P = 0.01$) of growth curves of untransformed weights.

Table 12 lists the age specific summary of percent composition, mean length, mean weight and mean condition factor of whitefish taken by experimental fishing in 1981. Thirteen age classes ranging from 2 to 14 years were represented in the catch. Covariance analysis of size data for common ages of 5-14 for 1981 commercial versus experimentally sampled fish showed no significant difference in slopes ($F = 3.10$, 1 and 16 d.f., $P = 0.01$) or elevations ($F = 0.71$, 1 and 17 d.f., $P = 0.01$) of growth curves of untransformed lengths and in slopes ($F = 2.04$, 1 and 16 d.f., $P = 0.01$) or elevations ($F = 0.28$, 1 and 17 d.f., $P = 0.01$) of growth curves of untransformed weights.

Linear regressions of log transformations of length-weight relationships between age groups from commercial samples (Table 13) indicated positive allometric growth through the 1975-1977 period, negative allometric growth for the 1980 sample and slopes near isometric form for 1978, 1979 and 1981. Whitefish growth data calculated from ages 5-12, ages with adequate sample size, from 1981 experimental sampling produced a length-weight relationship with

Table 12. Age composition, age specific mean fork lengths, mean weights and mean condition factors of whitefish from experimental nets Playgreen Lake, June 1981

Age	N	%	Mean length	ISE	Mean wt	ISE	Mean CF
2	6	2.42	216.67	6.92	116.67	13.94	1.12
3	18	7.26	227.72	2.23	141.67	9.48	1.18
4	1	0.40	262.00		250.00		1.39
5	12	4.84	353.83	7.23	602.08	38.37	1.34
6	20	8.06	377.50	4.81	772.50	38.17	1.42
7	32	12.90	391.66	4.38	823.44	28.15	1.36
8	41	16.53	401.46	3.27	899.39	25.74	1.38
9	54	21.77	415.54	2.48	1012.50	21.68	1.40
10	36	14.52	417.61	3.34	999.31	22.90	1.37
11	14	5.65	415.00	5.20	1041.29	39.46	1.41
12	11	4.44	461.09	9.68	1322.73	79.59	1.33
13	1	0.40	446.00		1300.00		1.47
14	2	0.81	499.00	31.00	2075.00	625.00	1.61
Mean 7.96			388.10		863.91		1.36

Table 13. Length-weight relationships of whitefish from Playgreen Lake commercial nets 1975-1981.

Year	Age	Length-weight equation	Correlation coefficient	Test F value and d.f.
1975	4-9	$\log_e$ weight = -13.821+3.442 $\log_e$ length	0.994	359.84(1,4) *
1976	4-12	$\log_e$ weight = -14.396+3.558 $\log_e$ length	0.994	590.34(1,7) *
1977	5-12	$\log_e$ weight = -13.937+3.469 $\log_e$ length	0.992	384.22(1,6) *
1978	4-13	$\log_e$ weight = -10.713+2.931 $\log_e$ length	0.980	193.88(1,8) *
1979	4-10	$\log_e$ weight = -10.775+2.967 $\log_e$ length	0.994	469.70(1,5) *
1980	3-10	$\log_e$ weight = - 9.161+2.675 $\log_e$ length	0.991	318.76(1,6) *
1981	5-14	$\log_e$ weight = -11.726+3.092 $\log_e$ length	0.980	190.96(1,8) *

* significant at P = 0.05.

isometric form (Table 14) nearly identical to that calculated from the commercial sampling data.

Linear regression of log transformed mean length at age data were used to compare whitefish growth rate differences among years 1975-1981 for age classes 5 - 9 from commercial nets (Table 15) and 1981 experimental nets (Table 16). No trend was defined in the slopes of the exponential growth curves for length but there was a general decline in slopes of the exponential weight growth curves from 1976 to 1981 (Table 17).

Covariance analyses of size data for age groups 5 - 9, common to all samples during 1975-81 showed no significant difference in slopes ($F = 3.35$, 6 and 21 d.f., $P = 0.05$) but significant differences in elevations ($F = 26.41$, 6 and 27 d.f., $P = 0.05$) of growth curves of untransformed lengths and significant differences in both slopes ($F = 9.74$, 6 and 21 d.f., $P = 0.05$) and elevations ($F = 27.54$, 6 and 27 d.f., $P = 0.05$) of growth curves of untransformed weights.

The von Bertalanffy growth model was also used to describe growth relationships as a function of the Brody growth coefficient (K) and asymptotic length (L_∞) for commercial samples and experimentally sampled fish. The age classes used in the Walford plots (Table 18 and 19) were selected iteratively for high correlations and realistic asymptotic lengths. The L_∞ calculated from commercial data ranged from 503 in 1975 and 1981 to 570 in 1979. The Walford

Table 14. Length-weight relationships of whitefish from Playgreen Lake experimental nets 1981.

Age range	Length-weight equation	Correlation coefficient	Test F value and d.f.
2-14	$\log_e$ weight = -12.790+3.271 $\log_e$ length	0.998	2984.46(1,11) *
5-12	$\log_e$ weight = -10.983+2.967 $\log_e$ length	0.993	441.70(1,6) *

* significant at P=0.05.

Table 15. Exponential growth (length-age) curves for Playgreen Lake whitefish from commercial nets, 1975-1981.

Year	Linear equation	Age-range	Correlation coefficient	Test F value and d.f.
1975	$\log_e$ length = 5.607+0.250 $\log_e$ age	5-9	0.985	95.30(1,3) *
1976	$\log_e$ length = 5.393+0.351 $\log_e$ age	5-9	0.985	198.61(1,3) *
1977	$\log_e$ length = 5.453+0.311 $\log_e$ age	5-9	0.991	169.90(1,3) *
1978	$\log_e$ length = 5.606+0.220 $\log_e$ age	5-9	0.943	23.92(1,3) *
1979	$\log_e$ length = 5.483+0.301 $\log_e$ age	5-9	0.997	488.58(1,3) *
1980	$\log_e$ length = 5.462+0.331 $\log_e$ age	5-9	0.958	33.07(1,3) *
1981	$\log_e$ length = 5.578+0.203 $\log_e$ age	5-9	0.974	111.70(1,3) *

* significant at P=0.05.

Table 16. Exponential growth (length-age) curve for Playgreen Lake whitefish from experimental nets, 1981.

Age-range	Linear equation	Correlation coefficient	Test F value and d.f.
5-9	$\log_e$ length = 5.452+0.264 $\log_e$ age	0.993	226.52(1,3) *

* significant at P=0.05.

Table 17. Exponential growth (weight-age) curves for Playgreen Lake whitefish from commercial nets, 1975-1981.

Year	Linear equation	Age-range	Correlation coefficient	Test F value and d.f.
1975	$\log_e$ weight = 5.451+0.878 $\log_e$ age	5-9	0.982	159.46(1,3) *
1976	$\log_e$ weight = 5.105+1.087 $\log_e$ age	5-9	0.997	539.17(1,3) *
1977	$\log_e$ weight - 5.171+0.983 $\log_e$ age	5-9	0.979	68.91(1,3) *
1978	$\log_e$ weight = 5.519+0.749 $\log_e$ age	5-9	0.960	35.73(1,3) *
1979	$\log_e$ weight = 5,343+0.971 $\log_e$ age	5-9	0.997	533.32(1,3) *
1980	$\log_e$ weight = 5.530+0.840 $\log_e$ age	5-9	0.984	94.09(1,3) *
1981	$\log_e$ weight = 5.632+0.580 $\log_e$ age	5-9	0.941	23.02(1,3) *

* significant at P=0.05.

Table 18. Linear regressions of Walford plots fitted by least squares regressions, Playgreen Lake whitefish lengths from commercial samples, 1975-1981.

Year	Age range	Linear equation	L_∞ (mm)	Correlation coefficient	Test F value and d.f.
1975	4-9	$L_{t+1} = 123.142+0.755\ L_t$	502.6	.981	78.21(1,3) *
1976	4-11	$L_{t+1} = 99.967+0.815\ L_t$	540.4	.986	177.38(1,5) *
1977	4-12	$L_{t+1} = 94.463+0.817\ L_t$	516.2	.980	147.10(1,6) *
1978	7-11	$L_{t+1} = 78.673+0.854\ L_t$	538.9	.969	30.99(1,2) *
1979	5-9	$L_{t+1} = 70.719+0.876\ L_t$	570.3	.985	65.22(1,2) *
1981	5-14	$L_{t+1} = 59.328+0.882\ L_t$	502.8	.953	69.67(1,7) *

* significant at P=0.05.

Table 19. Linear regressions of Walford plots fitted by least squares regressions, Playgreen Lake whitefish experimental sample 1981.

Age range	Linear equation	L_∞ (mm)	Correlation coefficient	Test F value and d.f.
2-14	$L_{t+1} = 71.439+0.869\ L_t$	545.34	0.938	73.18(1,10) *

* significant at P=0.05.

plot of 1980 age-length data paralleled the agreement line and L_∞ could not be calculated.

The Walford plot of age specific length data from the 1981 experimental sample produced a L_∞ of 545 mm.

Linear regressions of $\log_e (L_\infty - L_t)$ against age t for commercial data (Table 20) and experimental data (Table 21) provided the other parameters, K, and t_o (age of fish at length 0) used in the von Bertalanffy growth equation, $L_t = L_\infty (1-e^{-K (t-t_o)})$ (Table 22 and 23, Fig. 2 and 3).

Sex and Maturity

Sex and maturity summaries and age frequencies from the 1981 experimental fishing program are provided in Table 23. Males were represented to a greater extent than females in both number 1.48:1 and biomass 1.43:1. Females were slightly older and larger than males in the catch. Matures outnumbered the immatures 4.5:1. The mean age of maturity, sexes combined, interpolated from the maturity curve was less than the figure derived from Abrosov's modified formula (Table 25). The maturity curve indicated a high degree of correlation between age and maturity.

Table 20. Linear regressions of $\log_e (L_\infty - L_t)$ and t for Playgreen Lake whitefish from commercial samples, 1975-1981.

Year	Age group	Linear equation	Correlation coefficient	Test F Value and d.f.
1975	4-9	$\log_e (503-\ell_t) = 5.989-0.281_t$	1.000	556.03(1,4) *
1976	4-11	$\log_e (540-\ell_t) = 6.052-0.202_t$	0.993	459.06(1,6) *
1977	4-12	$\log_e (516-\ell_t) = 5.844-0.199_t$	0.986	255.35(1,7) *
1978	7-11	$\log_e (540-\ell_t) = 5.962-0.156_t$	0.995	299.69(1,3) *
1979	5-9	$\log_e (570-\ell_t) = 5.873-0.136_t$	0.997	517.80(1,3) *
1981	5-14	$\log_e (503-\ell_t) = 5.677-0.138_t$	0.962	99.71(1,8) *

* significant at P=0.05.

Table 21. Linear regression of $\log_e (L_\infty - l_t)$ and t for Playgreen Lake whitefish from 1981 experimental samples.

Age group	Linear equation	Correlation coefficient	Test F value and d.f.
2-14	$\log_e (545-l_t) = 6.077-0.134_t$	0.949	100.35(1,11) *

* significant at P=0.05.

Table 22. Von Bertalanffy growth parameters for Playgreen Lake whitefish from commercial nets for the period 1975-1981.

Year	N	Age Range	Parameters		
			K	L_∞	t_o
1975	233	4-9	.281	502.6	-0.826
1976	472	4-11	.202	540.4	1.188
1977	255	4-12	.199	516.2	2.020
1978	206	7-11	.156	538.9	2.115
1979	314	5-9	.136	570.3	3.478
1981	447	5-14	.138	502.8	3.934

Table 23. Von Bertalanffy growth parameters for Playgreen Lake whitefish from experimental nets 1981.

Age Range	N	Parameters		
		K	L_∞	t_o
2-14	248	0.134	545.3	1.67

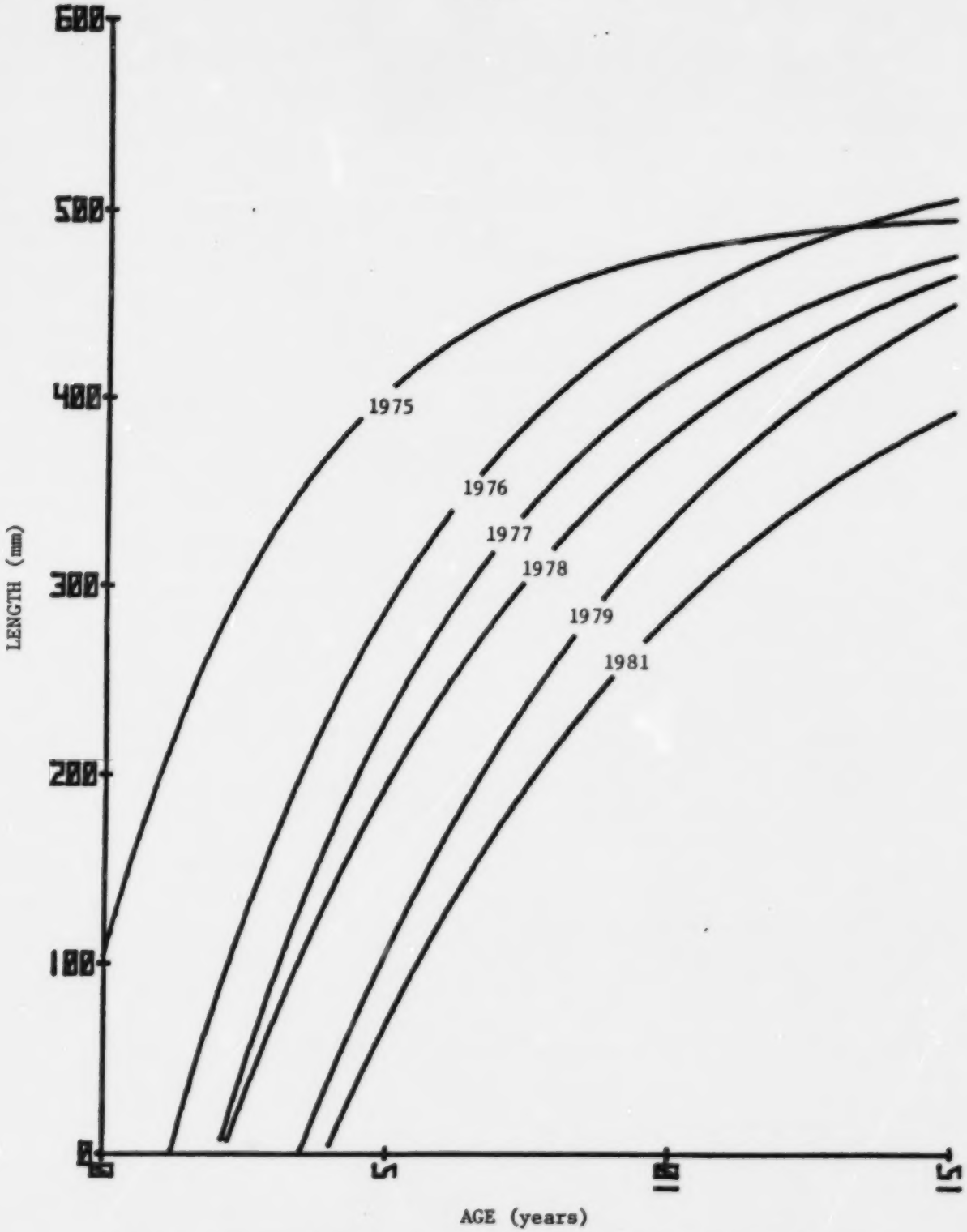

Fig. 2. Von Bertalanffy growth curves for whitefish from Playgreen Lake commercial samples 1975-1981.

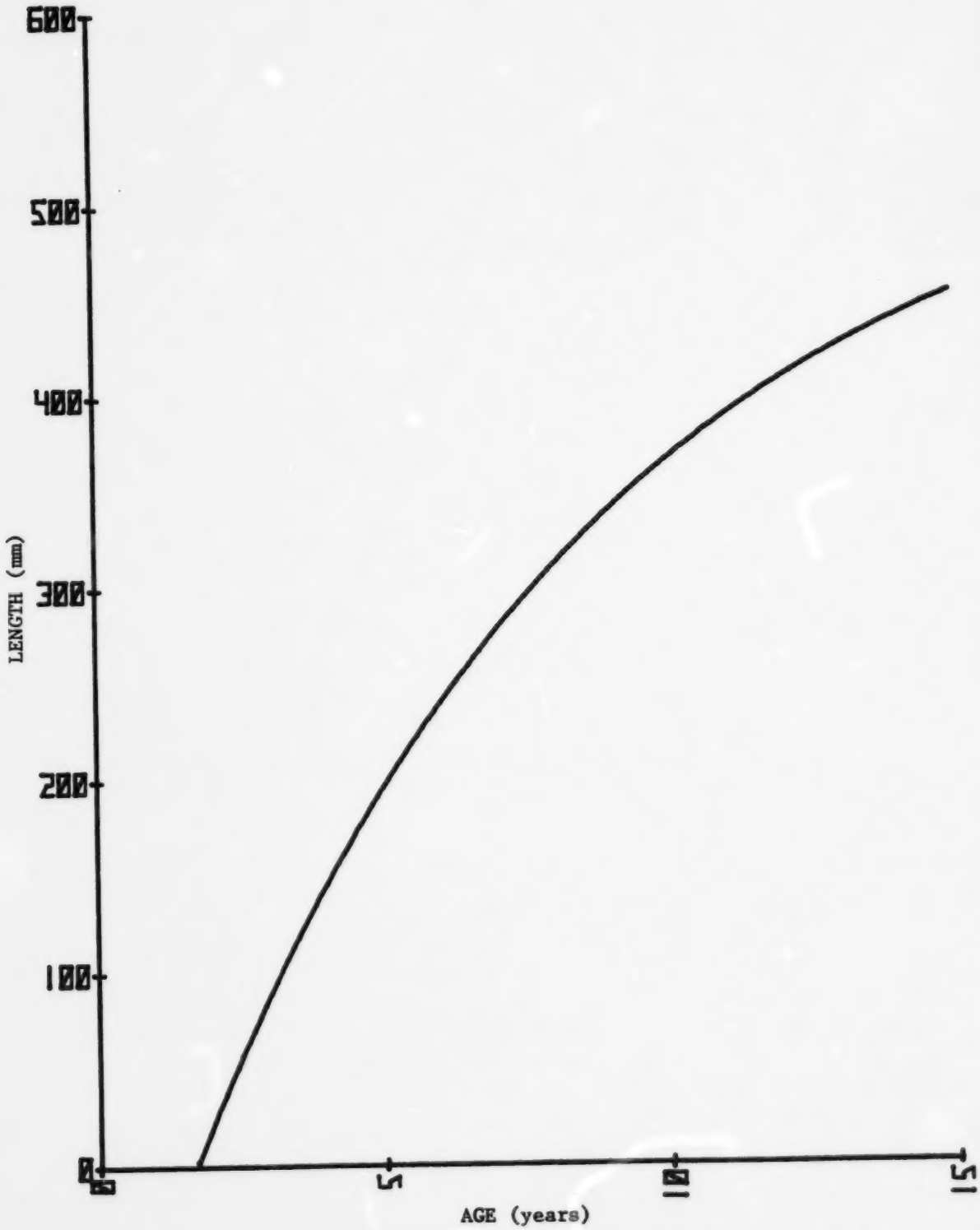

Fig. 3. Von Bertalanffy growth for whitefish from Playgreen Lake experimental sample, 1981.

Table 24. Sex and maturity frequencies, Playgreen Lake whitefish, 1981 experimental gangs.

	male	female	immature	mature
no. fish	148	100	53	195
mean age	7.91	8.04	5.19	8.72
mean length	387.61	388.83	308.43	409.75
mean weight	852.87	880.25	481.13	967.95
mean K	1.36	1.36	1.28	1.38
total biomass (kg)	126.22	88.03	25.50	188.75
% biomass	58.92	41.08	11.90	88.10

	Frequency				
Age(years)	male	female	immature	mature	% mature
2	3	3	6		
3	10	8	18		
4	1		1		0
5	8	4	6	6	50.0
6	12	8	5	15	75.0
7	19	13	6	26	81.25
8	31	10	3	38	92.68
9	29	25	3	51	94.44
10	19	17	4	32	88.89
11	8	6		14	100.00
12	6	5	1	10	
13	1			1	
14	1	1		2	

Table 25. Maturity curve for Playgreen Lake whitefish 1981.

Age range	Maturity curve $-\log_e \frac{(k-y)}{y} = a + b \cdot age$	Correlation coefficient	Age at 50% mature (years)	Test F value and d.f.	Abrasov's mean age of maturity (years)
5-9	Y = -3.386+0.710X	0.983	4.78	83.93(1,3)	6.17

Survival and Mortality

Survival and mortality rates calculated by Robson-Chapman and Regression methods from 1978-81 commercial samples and 1981 experimental samples from single and combined mesh are listed in Table 26. Estimates of survival rates by the two methods were significantly different for year classes 6 - 13 from the 108/134 mm combined mesh sample in 1978 and year classes 8 - 14 from the 108 mm mesh sample in 1981. Robson-Chapman survival estimates ranged from .272 for the 1980, 108 mm mesh samples, age groups 6 - 9, to .606 for the 1978 108/134 mm combined mesh samples, age groups 6 - 13. The lowest survival estimate using regression was .219 for the 1980, 108 mm mesh sample, age groups 6 - 9, and highest was .600 for the 1981, 134 mm mesh sample size, age groups 8 - 13. Survival rates in the September 1980 sample from single and combined meshes were lower generally than survival rates calculated from 1978, 79 or 81 samples.

Mesh Size Effects

Mean length, weight, age and condition factors of whitefish sampled from individual meshes in the September 1980 commercial sample increased with increasing mesh size (Table 27, Fig. 4). Fish caught in the 128 mm (5") mesh averaged 70.9 g heavier and 0.38 yr. older than fish in the 108 mm (4¼") mesh.

Mean length, weight and age increased regularly with increasing mesh size in the 1981 experimental sample (Table 28,

Table 26. Survival and mortality rates of Playgreen Lake whitefish from commercial and experimental nets 1978-1981.

Year	Mesh	Ages	Robson-Chapman			Regression		
			Z	A	S±2SE	Z	A	S
1978	108	6-13	.60	.456	.454<.544<.633	.632	.46	.53
	134	9-12	.89	.59	.209<.410<.630	1.069	.66	.34
	108/134	6-13	.50	.39	.539<.606<.673	.63	.46	.53
1979	108	6-9	1.01	.636	.146<.365<.582	1.86	.577	.423
	134	7-12	1.12	.676	.028<.327<.625	1.02	.639	.361
	108/134	7-12	.90	.593	.133<.405<.678	1.81	.555	.445
1980	96	5-6	1.61	.800	.026<.200<.426	1.39	.751	.249
	108	6-9	1.30	.728	.163<.272<.382	1.52	.781	.219
	128	6-9	1.28	.722	.037<.278<.520	1.03	.643	.357
	134	7-10	1.15	.683	.013<.316<.646	.96	.617	.383
	96-134	6-10	1.25	.714	.045<.286<.527	1.16	.687	.314
1981	108	8-14	0.67	.487	.470< .513<.556	.79	.546	.454
	134	8-13	0.57	.437	.459<.563<.665	.51	.400	.600
	108/134	9-14	0.80	.552	.393<.448<.504	.89	.589	.411
	51-134 (Exp.)	9-14	0.72	.511	.422<.489<.556	.70	.503	.497

Table 27. Playgreen Lake whitefish mesh size effects, 1980 commercial sample.

	Mesh size (mm)			
	96	108	128	134
no fish	70	247	246	248
mean length (mm)	396.11	406.97	415.21	428.8
mean weight (gm)	838.00	973.24	1044.15	1154.8
mean C.F.	1.34	1.44	1.45	1.50
	Frequency (%)			
Age (years)				
3	4.29	0.40		0.40
4	45.71	19.84	11.38	5.24
5	40.00	53.44	45.53	31.45
6	10.00	23.89	32.11	38.71
7		1.62	6.91	16.53
8		0.81	3.66	5.24
9			0.41	1.21
10				1.21
Mean age (years)	4.56	5.09	5.47	5.92

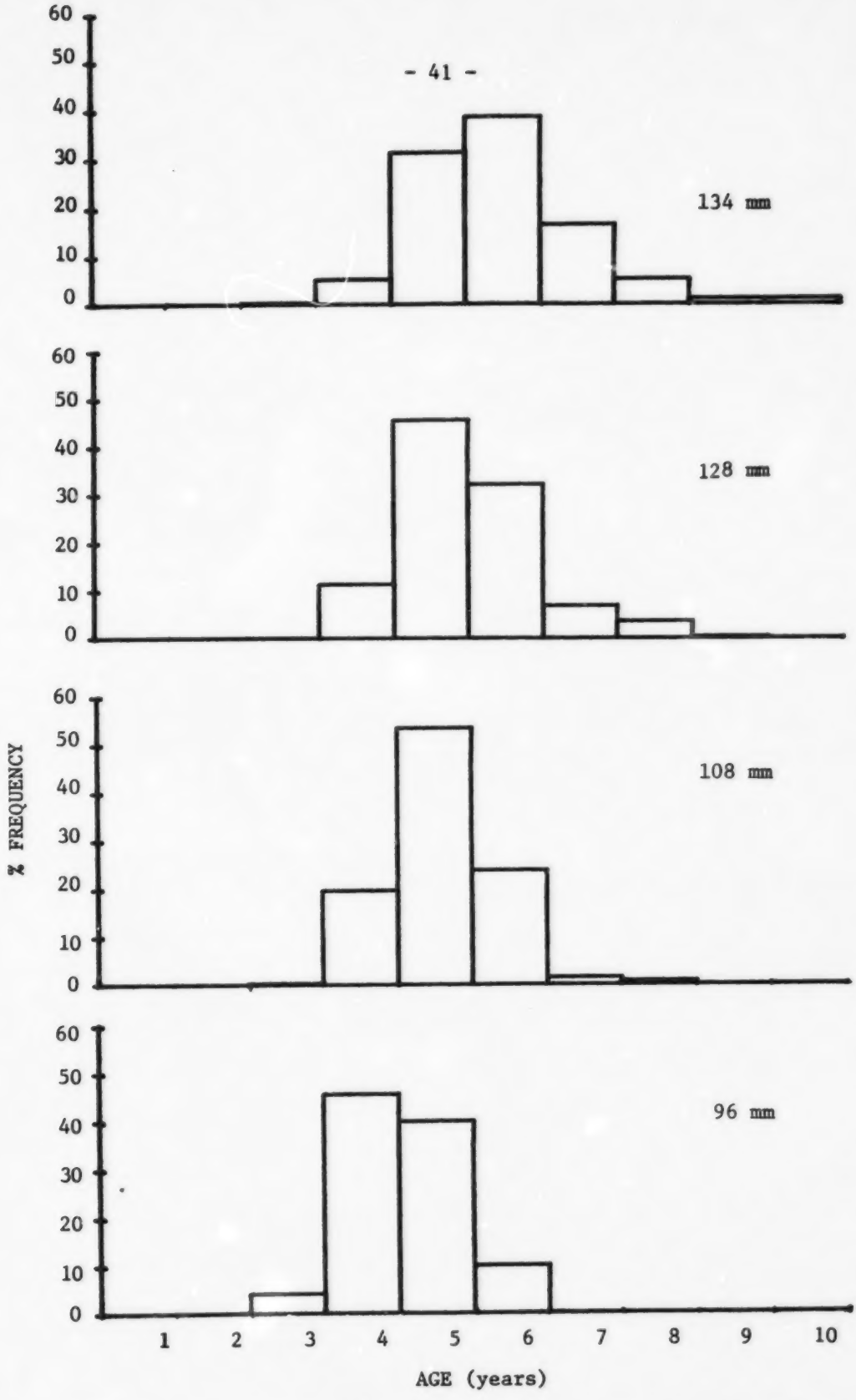

Fig. 4. Mesh size effects on whitefish from the 1980 commercial sample.

Table 28. Playgreen Lake whitefish mesh size effects, 1981 experimental sample.

	Mesh size (mm)						
	51	77	96	108	121	134	108/121/134 combined
no. fish	26	18	72	78	42	12	132
mean length (mm)	232.96	373.22	396.88	410.99	421.71	427.50	415.90
mean weight (gm)	167.31	733.33	871.18	965.06	1073.21	1135.42	1014.96
mean C.F.	1.18	1.38	1.37	1.38	1.40	1.45	1.39
% immature	96.1	42.1	13.9	11.5	2.38	8.3	8.3
% biomass	2.03	6.16	29.28	35.13	21.04	6.36	62.53
mean biomass mesh^{-1}	0.621	1.886	8.961	10.754	6.439	1.946	6.380
mean no. fish mesh^{-1}	3.71	2.57	10.28	11.14	6.0	1.71	6.29
	Frequency (%)						
Age (years)							
2	23.08						
3	69.23						
4	3.85						
5		16.67	6.94	2.56	4.76		3.03
6		11.11	16.67	3.85	4.76	8.33	4.55
7	3.85	16.67	16.67	15.38	9.52		12.12
8		22.22	22.22	20.51	9.52	8.33	15.91
9		11.11	20.83	25.64	28.57	41.67	28.03
10		16.67	8.33	19.23	21.43	25.00	20.45
11			5.56	6.41	9.52	8.33	7.58
12		5.56	1.39	5.13	9.52	8.33	6.82
13			1.39				
14				1.28	2.38		1.52
Mean age (years)	2.96	7.78	7.96	8.64	9.19	9.33	8.98

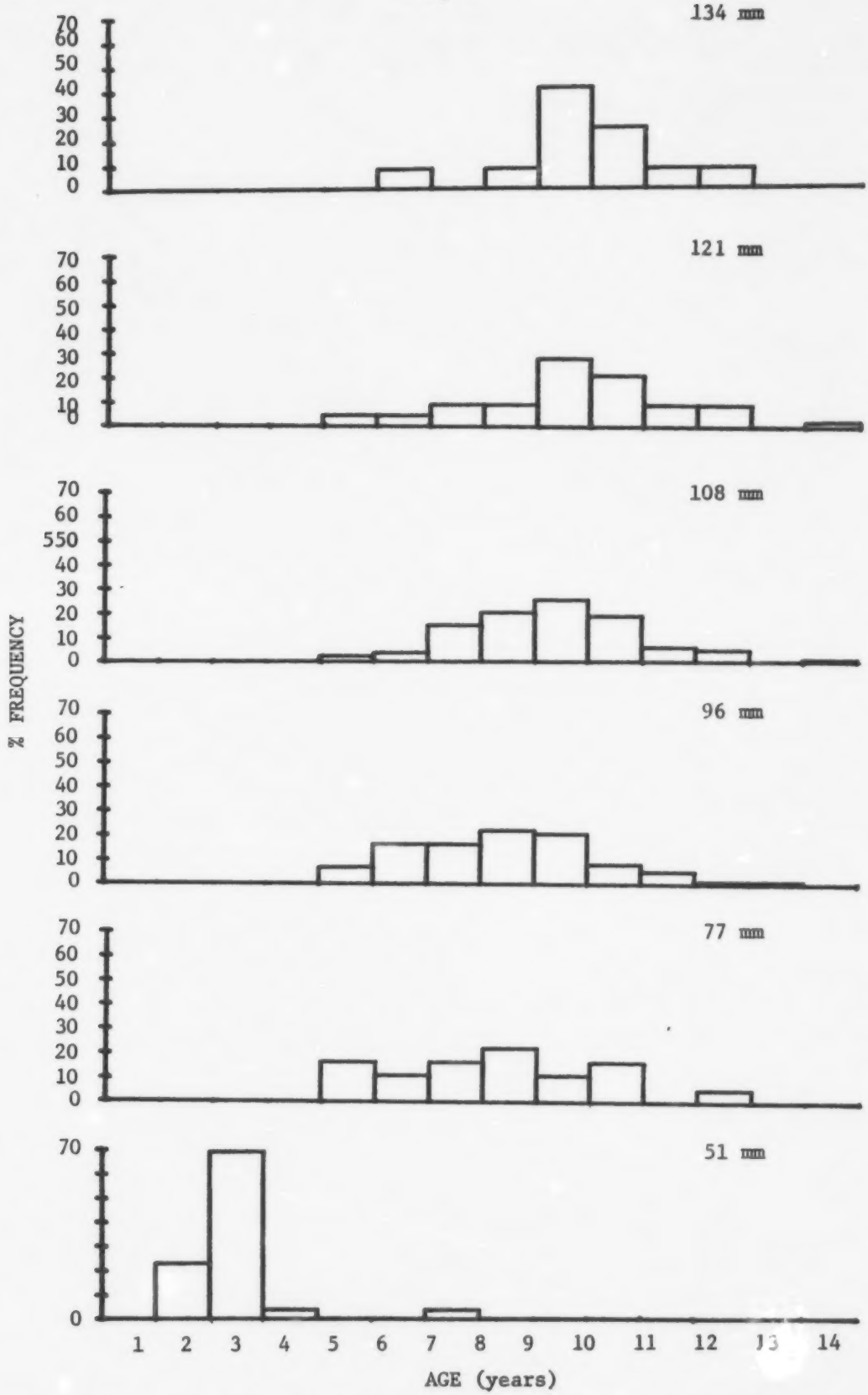

Fig. 5. Mesh size effects on whitefish from the 1981 experimental sample.

Fig. 5). Over 86% of fish caught in 96 mm and larger mesh were mature. The 108 mm mesh captured the largest biomass mesh^{-1}, 10.75 kg, [1](35.13% of total) and number mesh^{-1} (11.1). Three meshes, 96 mm, 108 mm and 121 mm harvested the greatest proportion (85.45%) of the total catch.

Yields

The estimated total number of fish in the catch was considerably higher during 1978, 1980 and 1981, when fishermen harvested approximately 225,000 fish, than in other years estimated (Table 29). The 1976 harvest produced the fewest number of fish, 140,000. The modal age in the commercial catch increased from 5 to 8 years from 1975 to 1977, decreased to 5 years in 1980 and then increased abruptly to 8 years in 1981.

The number of deliveries, an indication of effort, decreased from 1300 in 1974 to 1036 in 1976, increased by 692 deliveries from 1978 to 1979 and peaked in 1981 at 1986 deliveries (Table 30). The biomass delivery^{-1} increased from 138.4 kg in 1974 to a high of 207.3 kg in 1977, when fishermen were granted a quota extension of 45,360 kg, and declined thereafter to 106.4 kg in 1981. Numbers delivery^{-1} were much lower during 1979-81 averaging 110 fish than during the previous 4 years when the average was 154 fish.

Comparisons of weighted means of weekly catch delivery^{-1} values demonstrated that catches were high during June for the

Table 29. Estimated number of whitefish per age class taken in the commercial fishery 1975-1981. Modal age is underlined.

Year	Age 3	4	5	6	7	8	9	10	11	12	13	14	Total N
1975		4,496	61,447	59,948	30,725	14,238	3,746						174,600
1976		927	1239	24,779	47,388	33,451	17,035	12,389	2168	620			139,996
1977		652	5879	28,092	37,890	44,381	28,091	15,026	3266	3266			166,542
1978		1094	29,099	77,441	36,806	23,058	24,718	20,872	7691	1646	554		222,979
1979	1009	18843	47,403	55,637	34,644	15,805	7137	2034	512	507			182,931
1980	893	28,140	95,391	70,360	20,440	6808	1369	1356					224,757
1981			6,117	23,575	40,504	63,364	48,995	25,850	11,664	5069	2024	498	226,851

Table 30. Playgreen Lake whitefish yields and catch per delivery, 1973-1981.

Year	Yield (kg. rd. wt.)	No. deliveries	Catch/delivery (kg)	Total N	N/delivery
1973	190,084	1249	152.2		
1974	179,856	1300	138.4		
1975	190,750	1182	161.4	174,600	148
1976	208,071	1036	200.8	140,000	135
1977	221,825	1070	207.3	166,540	156
1978	240,284	1275	185.5	222,980	175
1979	212,653	1967	107.6	182,930	93
1980	239,146	1814	131.8	224,760	124
1981	211,360	1986	106.4	226,850	114

Table 31. Playgreen Lake weekly whitefish yields and catch per delivery, 1976-1981.

Date	June															
	1-7				8-14				15-21				22-30			
Year	Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$	
			kg	N			kg	N			kg	N			kg	N
1976	17,644	99	178.2	122.8	50,988	294	173.4	119.5	28,965	176	164.6	113.4	46,281	251	184.4	127.1
1977	2,161	14	154.4	116.9	43,060	224	192.2	145.4	34,771	141	246.6	186.5	42,234	178	237.3	179.5
1978	639	3	213.0	197.8	14,765	86	171.7	158.9	36,296	240	151.2	140.4	53,078	271	195.9	181.9
1979	130	4	32.5	26.8					3,379	27	125.1	103.3	50,102	447	112.1	92.6
1980	22,569	133	169.7	159.5	42,426	291	145.8	137.0	28,023	177	158.3	148.8	42,572	264	161.3	151.6
1981	49,212	243	202.5	217.5	30,790	218	141.2	151.7	12,533	179	70.1	75.3	39,404	367	107.4	115.4
Mean			186.2				163.5				153.2				153.9	

Date	July															
	1-7				8-14				15-21				22-31			
Year	Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$	
			kg	N			kg	N			kg	N			kg	N
1976	33,461	157	213.1	146.8												
1977	35,542	201	176.8	133.7	10,581	69	153.3	116.0	17,775	105	169.3	128.1	19,810	138	143.6	108.6
1978	32,245	204	158.1	146.8	29,458	196	150.3	139.6	19,289	169	114.1	105.9				
1979	28,645	203	141.1	116.5	20,997	273	76.9	65.7	21,368	245	87.2	72.0	14,738	181	81.4	69.4
1980	41,427	292	140.8	132.3	35,135	279	125.9	118.3	13,691	194	70.6	66.4	15,802	135	117.1	110.1
1981	24,973	262	95.3	102.4	6,356	196	32.4	34.5	5,259	176	29.9	32.1	6,542	170	38.5	41.4
Mean			126.9				101.2				87.0				91.2	

cont'd.

Table 31 (cont'd.)

August

Date	1-7				8-14				14-21				22-31			
Year	Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$	
			kg	N			kg	N			kg	N			kg	N
1976	782	1	782	538.9	26,862	58	463.1	319.1								
1977																
1978									26,656	110	242.3	225.0	282	1	282	261.8
1979	12,685	148	85.7	70.8					2,953	26	113.6	93.8	64,586	413	156.4	129.1
1980	8,810	47	187.4	176.1												
1981	2,884	16	224.2													
Mean			118.7				463.1				217.7				156.7	

September

Date	1-7				8-14				14-21				22-31			
Year	Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$		Yield	N. del.	Catch del.$^{-1}$	
			kg	N			kg	N			kg	N			kg	N
1976																
1977																
1978	527	2	263.5	224.7	2,650	6	441.7	410.1	2,436	6	406.0	377.0	547	1	547	507.5
1979															1,171	967.0
1980																
1981									33,865	151	224.2					
Mean			263.5				441.7				231.1				859.0	

period 1976-1981 and then dropped abruptly after the first week of July (Table 31). The distribution of effort during August was too sporadic to detect definite trends but catches did appear to improve as the month progressed. A few deliveries were made during September in 1978 and the catch delivery^{-1} was the highest on record. In recent years, a greater proportion of the fishing effort, in terms of number of deliveries, is being exercised during July. This reallocation of effort was particularly evident in 1979 when only 31 of the total of 1967 deliveries were made during the first 3 weeks of June and, in an attempt to achieve the quota, fishing continued throughout July and August.

DISCUSSION

Growth

Slopes of the length-weight curves showed a substantial decline between 1977 and 1978 as the pattern changed from positively allometric to isometric in form. Older fish in the catch in 1978 were significantly smaller than in 1977. This change in size would have been quite noticeable to the fishermen as the mean size of fish caught declined 24 mm in length and 245 g in weight. The negatively allometric condition found in the 1980 sample is probably a misrepresentation of Playgreen Lake fish. The sample was taken in late September, consisted entirely of spawners, and a large percentage of the catch may have been fish originating from Lake Winnipeg (D. Cook, pers. comm.). D. Allen (pers. comm.) confirmed that a heavy spawning migration of whitefish from Lake Winnipeg runs downstream into Playgreen Lake in September every year. Statistical parameters which corroborated the suggestion that these were from the Lake Winnipeg population were mean age, weight, length and condition factor which were almost identical to those calculated from the 1980 Lake Winnipeg commercial sample (O'Connor 1981). The slight increase in mean length and weight of this sample over the Lake Winnipeg samle could represent growth since the Lake Winnipeg whitefish were sampled earlier in the season. The identical age range and mean age of the catch for the 2 samples is evidence of ageing precision since different structures were used in aging

samples from the two fisheries.

Growth analysis were based on data gathered for fish large enough to be recruited to a 108 and 134 mm mesh in the commercial fishery. The fastest growth, in length, of whitefish occurs before 5 years of age so the growth comparisons from the 1977-1981 commercial sample is for year classes of a size when the rates of change are relatively slow. This accounts for the lack of significant difference in slopes of length growth curves. The elevations of length-growth curves and slopes and elevation of weight growth curves declined through the 1975-1981 period. The decline in weight growth exponential between 1976 and 1977 may be partially explained by the change in age structure from seales to fin rays, but there was a substantial decline in weight growth exponential from 1977 to 1981 which is real and reflects changing characteristics in the fish stock. Growth rate declines calculated from the commercial sample do not appear to be a sampling artifact introduced from the increased use of 108 mm mesh since there was no significant difference in growth rates of fish taken from 108, 128 or 133 in the 1980 commercial sample. Furthermore, the June 1977 sample, selected totally from 108 mm mesh, had one of the fastest growth rates recorded.

The correlation coefficients calculated from regressions of $\log_e (L_\infty - L_t)$ versus t were higher than those calculated for $\log_e$ length versus age suggesting that the von Bertalanffy growth

equation better describes the growth pattern than the exponential equation. The Brody growth constant indicated the same growth trend as the growth rate shown by the declining slope of the exponential equation. It is difficult to compare the results of the two transformations, though, since different year classes were used to develop the best linear fit. Although correlation coefficients were high for regressions used in developing the von Bertalanffy growth equation, t_o is unrealistic for most years and brings into question the advantage of using this transformation to describe growth from commercial samples. The t_o calculated from 1981 experimental data, 1.67, is more acceptable and the 1981 von Bertalanffy equation developed from experimental data would better describe the growth pattern than the equation developed from 1981 commercial data.

Maturity

The maturity curve fitted to 1981 experimental data showed a slower rate of maturity than rates calculated from Lake Winnipeg whitefish for 1979 and 1980 (Lysack 1981). The mean age at maturity was slightly older than the mean age at maturity for Lake Winnipeg whitefish in 1979 but 1.7 years less than that calculated for Lake Winnipeg whitefish in 1980. Abrasov's mean age at maturity, 6.17 years, was slightly less than that calculated for Lake Winnipeg.

Abrasov's (1967) t index for 1981 Playgreen Lake whitefish

is +2.1, indicating that brood stocks are healthy and are not being overfished.

Survival Rates

Survival rates calculated from the 1980 sample were the lowest of rates calculated for 1978-1981 and were similar statistically to those calculated from Lake Winnipeg commercial samples from 1979 and 1980 (Lysack 1980, 1981). Both Robson-Chapman and regression survival estimates for 1978, 1979 and 1981 were moderately high but fell within the range calculated for exploited populations in Cedar Lake (Lysack 1980, 1981) and Lesser Slave Lake (Bell et al. 1977). Comparative survival rates of these populations requires a cautious interpretation, however, since if older year classes are present in the population survival rates calculated from samples aged with scales may be underestimated.

Mesh Size Selectivity

The 1980 commercial sample was taken from a spawning run and mesh size selectivity for maturity indices could not be determined. Age group size ranges may have been more uniform for this sample than if the sample was a random selection of matures and immatures since maturity is frequently size related (Bell et al. 1977). Nevertheless, samples from the meshes used in the 1980 commercial sampling program did show consistent increases in length, weight, age and isometric condition factors with increasing mesh size. Declines in size of

fish from Playgreen Lake is becoming a marketing problem (B. Popko, pers. comm.) which may have to be resolved by increasing the minimum legal mesh size to 128 mm to avoid smaller fish in the catch.

There were marked differences in mean biomass, maturity and age mesh $^{-1}$ between catches in the Lake Winnipeg experimental nets (Lysack 1981) and Playgreen Lake experimental gangs.

In Playgreen Lake, experimental fishing took place on whitefish grounds in early June when success is high. Nevertheless, the mean number of fish mesh^{-1} and mean biomass mesh^{-1} in Lake Winnipeg were almost triple the values for Playgreen Lake. The mean biomass mesh^{-1} for 5 meshes ranging from 77 to 134 mm on Playgreen Lake was 6.0 kg compared to 16.2 kg for a similar range of meshes and length of nets on Lake Winnipeg. The mean number of fish mesh^{-1} on Playgreen Lake was 6.34 versus 18.58 from Lake Winnipeg. A much higher percentage of immature fish were taken from all meshes in Lake Winnipeg experimental gangs than in Playgreen Lake gangs and the mean age mesh^{-1} was almost 3 years older in Playgreen Lake than Lake Winnipeg. With the exception of the mean weight of fish in 134 mm mesh, the average size of fish mesh^{-1} also was larger in Playgreen Lake experimental gangs than Lake Winnipeg experimental gangs.

The lack of annual experimental fishing data makes it difficult to assess the importance of the discrepancy between Lake Winnipeg biomass mesh^{-1} data and Playgreen Lake data. Intensified

intraspecific competition from expanding whitefish populations in Lake Winnipeg have led to density-dependent responses of growth and condition factor declines (O'Connor 1981). It is quite possible, therefore, that these biomass mesh^{-1} and number mesh^{-1} comparisons may reflect on unusually high concentration of whitefish in Lake Winnipeg rather than low density in Playgreen Lake. Biomass mesh^{-1} and number mesh^{-1} of whitefish in 1971 experimental netting in Playgreen Lake (Schlick 1972) were much less in both number, 2.25 mesh^{-1}, and biomass, 2.22 kg mesh^{-1}, than in 1981 but Schlick (pers. comm.) did his netting in 34 random locations around the lake to impartially sample all species and he did not fish, specifically, in whitefish zones as was done in 1981 (D. Cook, pers. comm.). The average size of whitefish captured in combined 108, 121, and 134 mm mesh in Schlick's 1971 study was slightly heavier, 81 g, than whitefish captured in these mesh sizes in 1981 experimental nets.

Yields

The modal age, mean age, number of older year classes and mean weight of fish caught commercially increased from 1975 to 1976. The 17% (23 kg) increase in catch delivery^{-1} from 1975 to 1976 can be explained by the 28% (328 g) increase in mean weight of fish in the catch. This size increase meant that fewer deliveries had to be made to produce a larger catch. In 1977 the modal age of fish in the catch was 1 year older (8 years) than in 1976. Average weight of fish remained high (1322 g) and only 1070 deliveries had to be made

to reach the quota. In 1978 the mean length, weight and age of the catch declined from the previous year, however, because of the large number of older fish (> 9 years) in the catch the number of fish delivery^{-1} was quite high (175) and the amount of effort, 1275 deliveries, needed to produce a record catch, 240,284 kg, was consistent with catches during the previous 5 years.

The increase in mean weight between 1978 and 1979 and substantially larger condition factors calculated from the 1979 commercial sample may be indicative of the seasonality of lipid concentrations in whitefish (O'Connor 1980) and these parameters may have been lower if the sample was taken in June. This infers that the total number of fish caught and number delivery^{-1} may have been slightly higher in 1979 than shown in Table 29 and 30. Notwithstanding a minor increase in estimates of numbers caught, there was a marked decline in number delivery^{-1} and biomass delivery^{-1} (-41.6%) between 1978 and 1979 that resulted in a substantial increase in effort, 692 deliveries, in order to fill the quota. The decline in numbers appeared to be partially related to the decline in strength of older year classes in the fishery from the previous year.

The catch delivery^{-1} improved in 1980 to 131.8 kg but since the 1980 sample was unrepresentation of the age and size structure of indigenous Playgreen Lake stocks this information could not be used in evaluating the change in catch. The 1981 catch delivery^{-1} and total catch values were almost identical to those from 1979. The

number delivery^{-1} in 1981 was larger than in 1979 but, as mentioned above, this could be an artifact introduced into analysis from seasonal growth occuring between early June and mid-July sampling periods.

The modal age, year class structure and mean age of catch had increased 2 years from 1979 to 1981 indicating that the same cohorts have supported the fishery from 1979-1981. The mean length and weight reduction in the catch over the period may be related to changes in growth characteristics and selective exploitation from the fishery of the faster growing fish in recruited cohorts. Four-year-olds were not recruited to the commercial fishery in 1981, an indication that declining growth rates have reduced the vulnerability of younger year classes to the nets.

It is difficult to answer the question as to whether or not environmental depreciation could have reduced trophic levels in Playgreen Lake and subsequent growth rates in whitefish, and then prevented any compensatory growth improvements that may have resulted from density declines. In fact, numbers delivery^{-1} from commercial nets may be a misleading indicator of density changes in the lake. The shallow depth, silty bottom and large stretches of unsheltered water contributes to poor catches during windy weather when nets quickly clog with debris, silt and vegetation (D. Allen, pers. comm.). Furthermore, weekly catch per delivery data shows that the decline in annual number delivery^{-1} in recent years is primarily due to the increase in fishing effort during July when both biomass delivery^{-1}

and number delivery^{-1} drops off. The most dramatic decline in biomass delivery^{-1} and number delivery^{-1} occurred in 1979 when a late spring delayed fishing until the third week of June and most of the fishing was done during July. Fishing commenced in early June in 1980 and 1981 but with a larger quota to harvest and smaller fish in the catch, fishing had to continue into July and August. There was no evidence of a declining trend in number delivery^{-1} during June from 1976 through 1981, however, with more fishing being done during summer months the annual average of number delivery^{-1} has declined. Whitefish catch declines during warmer summer months, particularly July, may be related to various biological, climatic or fishery conditions. Increased catches in the Warren Landing area suggests that whitefish move back into Lake Winnipeg (D. Cook, pers. comm.) and decreased netting efficiency during windy weather or changes in fishing sites in pursuit of higher priced walleye may also play a role in the declines in whitefish yields during this period.

Recommendations

1. Landsat digital data should be used for quantitative mapping of sediment levels in Playgreen Lake. This technique can be used to monitor sediment levels as a measure of water quality changes dating back to a period prior to the opening of 2-mile channel.

2. Experimental fishing should be carried out in June annually to monitor changes in whitefish growth, maturity and density.
3. Minimum mesh size should be increased to 128 mm in whitefish zones to improve marketing quality and permit a greater escapement of immatures.
4. Whitefish fishing should begin as early in June as possible and intensified during seasonal periods when catches are highest.
5. A method for restricting the use of 108 mm mesh to walleye zones should be developed with the Fishermen's Association.

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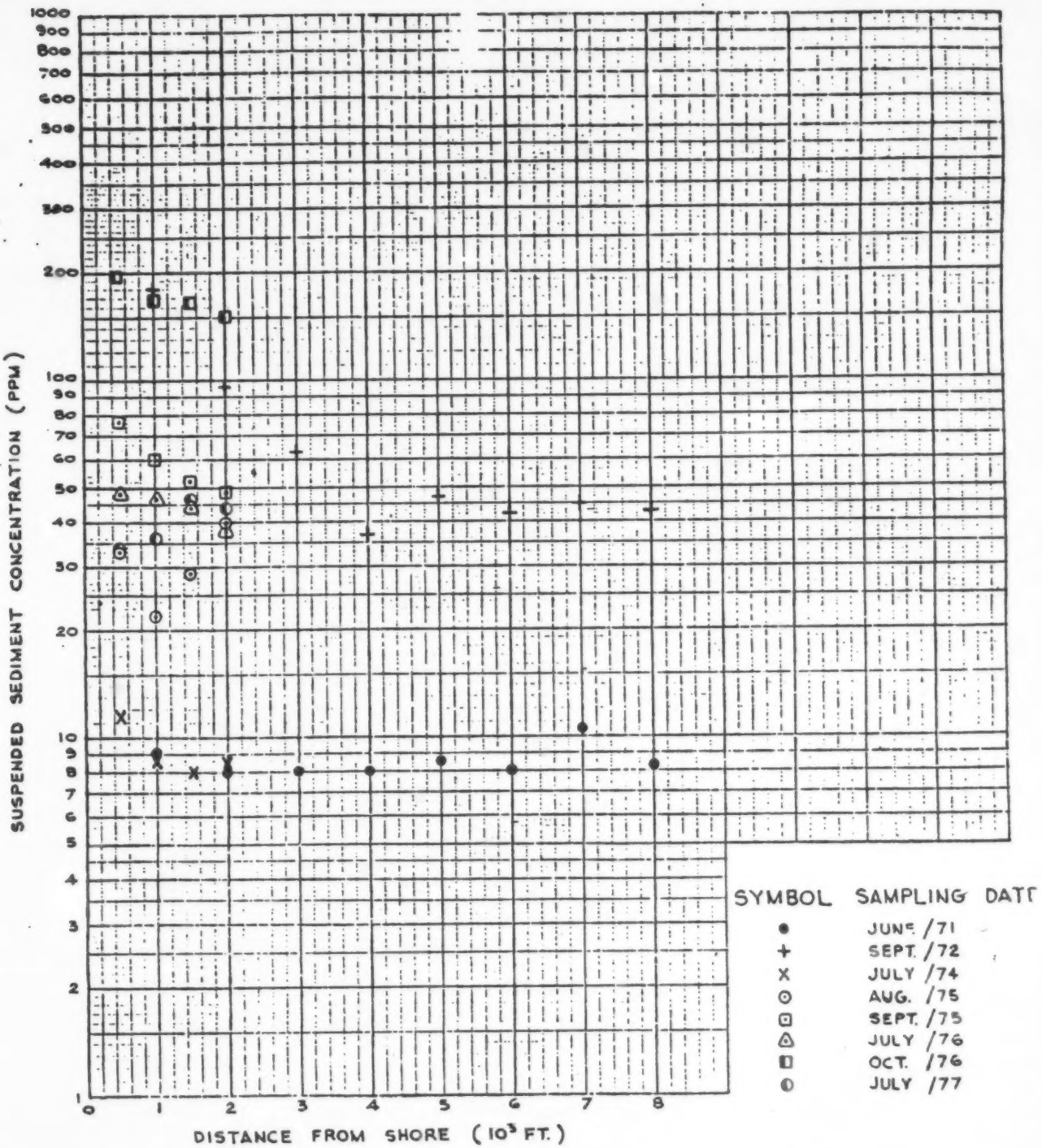
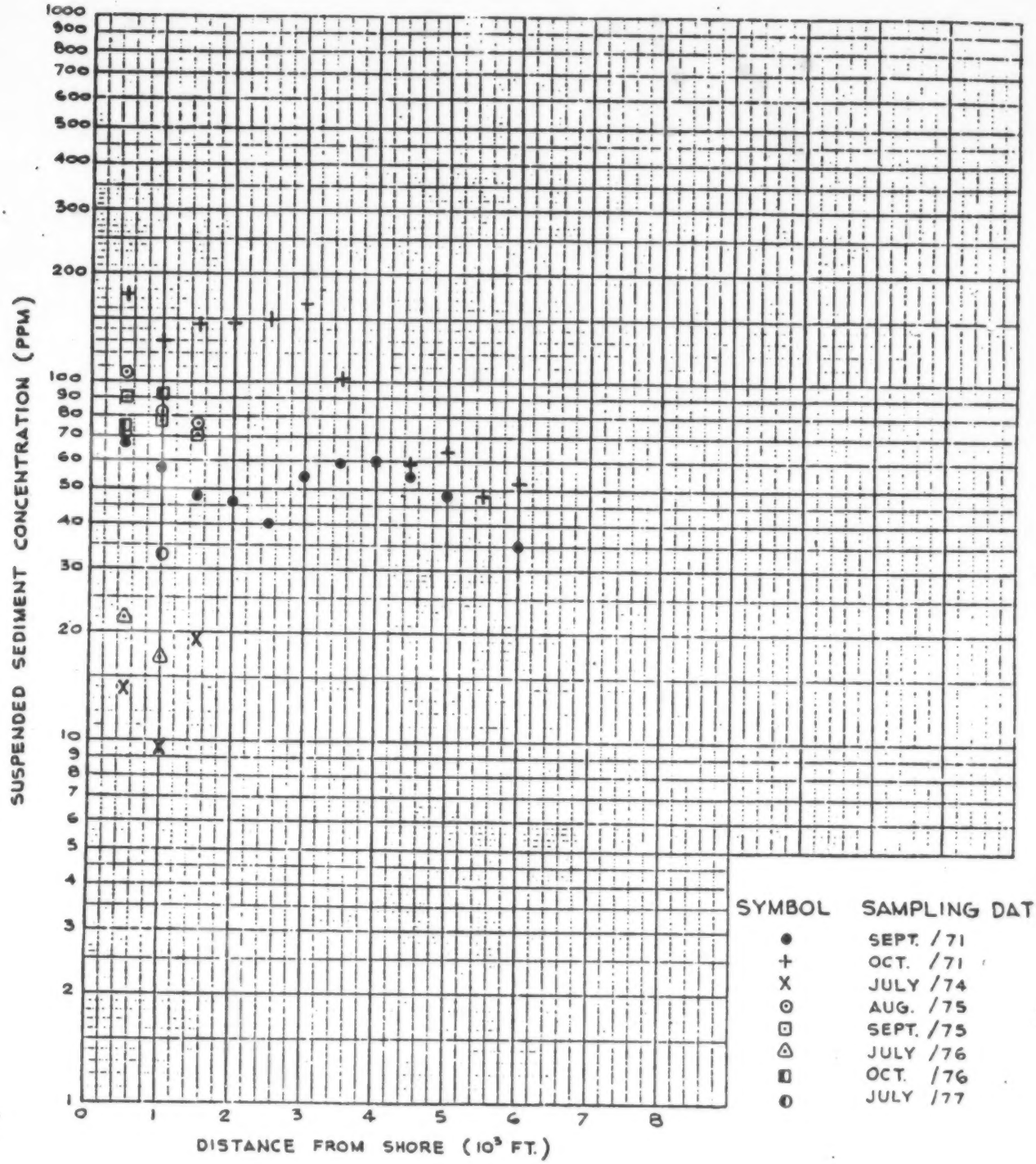


Appendix 1. LAKE WINNIPEG REGULATION
TWO MILE CHANNEL OUTLET
1971 - 1977 DATA
SUSPENDED SEDIMENT CONCENTRATION



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TWO MILE CHANNEL INLET
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SUSPENDED SEDIMENT CONCENTRATION